JOINT PANEL

ON

OCCUPATIONAL AND ENVIRONMENTAL RESEARCH

FOR URANIUM PRODUCTION IN CANADA

1987 ANNUAL REPORT

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Canada Centre for Mineral & Energy Technology
Energy, Mines and Resources Canada

on behalf of:
The Joint Panel on Occupational & Environmental
Research for Uranium Production in Canada

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FOREWORD

1987 Annual Report of the Joint Panel

I am pleased to submit the 1987 Annual Report of the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada. These annual reports have been recognized as a valuable source of information for the members and others interested in this subject. and. as such. receive wide circulation. At a time when cooperation is being fostered among Provincial and Federal regulatory and research agencies. industry members and universities. it is worth pointing out that the Joint Panel has been performing this function for over 10 years as a voluntary association of organizations with an active and continuing involvement in research on the occupational and environmental effects of uranium production. Members accept the obligation to inform each other of progress in their on-going work. to contribute to the development of a comprehensive program of research and to make final research results available to the public.

The Panel wishes to thank the Saskatchewan Research Council as well as CANMET for hosting the 1987 sessions of the Panel.

The Panel gratefully acknowledges the contribution made by Dr. J.E. Udd of CANMET's Mining Research Laboratories for providing the services of Dr. R. Tervo as Secretary. and for publishing the Annual Report.

L.D. Brown.
Chairman

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

EXECUTIVE - 1987

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Provincial Agencies Representative: Dr. L.D. Brown, Saskatchewan Labour.

Federal Agencies Representative*: Dr. J. Bigu, CANMET, EMR Canada.

Union Representative*: Mr. H. Seguin, USWA.

*See membership list, page 45, for addresses and telephone numbers.

SUPPORTING MEMBER ORGANIZATIONS, 1987

Atomic Energy of Canada Limited (AECL)
Atomic Energy Control Board (AECB)
Canadian Institute for Radiation Safety (CAIRS)
Denison Mines Limited (DEN)
Eldorado Resources Limited (ERL)
Energy, Mines and Resources Canada (EMR)
Environment Canada (DOE)
Health and Welfare Canada (NHW)
Indian Affairs and Northern Development Canada (DIAND)
Key Lake Mining Corporation
Ministry of Labour, Ontario (MOL)
Rio Algom Limited (RIO)
Saskatchewan Environment (SE)
Saskatchewan Human Resources, Labour and Employment (HURLE)
Saskatchewan Mining Development Corporation (SMDC)
United Steelworkers of America (USWA)

ASSOCIATE MEMBER ORGANIZATIONS, 1987

Cigar Lake Mining Corporation, Saskatchewan
Department of Consumer Affairs and Environment, Newfoundland and Labrador
Department of Mines and Energy, Newfoundland and Labrador
Department of Mines and Petroleum Resources, British Columbia
Labour Canada
Mines Accident Prevention Association of Ontario
Ministry of the Environment, Ontario
Ministry of Northern Development and Mines, Ontario
Saskatchewan Research Council
Saskatchewan Mining Association
Technical Advisory Committee on the Nuclear Fuel Waste Management Program
Uranerz Exploration and Mining Limited

TERMS OF REFERENCE

1.0 INTRODUCTION

1.1 The name of the panel shall be "The Joint Panel on Occupational and Environmental Research for Uranium Production in Canada".

1.2 Where appropriate, the name of the panel may be shortened to "The Joint Panel".

1.3 The Joint Panel is a Canadian organization whose members have voluntarily agreed to share information regarding research into the effects of uranium production on the health and safety of workers and the protection of the environment.

2.0 OBJECTIVES

2.1 The primary objectives of the Joint Panel shall be:

(a) identification of those areas related to the occupational health and environmental effects of uranium production in which there is a need for research; and

(b) stimulation of research in areas in which a need has been identified.

(c) the production areas of interest are mining and milling.

2.2 To meet its primary objectives the Joint Panel will:

(a) produce and distribute an annual inventory of current and completed research in relevant areas being conducted by Supporting Members (the Annual Report); and

(b) provide a forum for the exchange and dissemination of information on proposed, current and completed research.

3.0 MEMBERSHIP

3.1 Supporting Membership is open to any organization that actively and continually supports research on the occupational or environmental effects of uranium production.

3.2 Associate Membership is open to those organizations who:

(a) have responsibility or authority relating to occupational or environmental effects of uranium production, but do not actively support research activities; or

(b) are interested in the activities of the Joint Panel, but do not qualify as, or do not wish to become, a Supporting Member.

3.3 Admission to membership in the Joint Panel shall be granted by simple majority vote of the Supporting Members present at any meeting of the Joint Panel.

3.4 Any Supporting Member who is not active in the work of the Joint Panel may be reclassified as an Associate Member by simple majority vote of the Supporting Members present at any meeting of the Joint Panel if such action is requested by the Executive.

3.5 Participation on the Joint Panel will in no way constrain members from pursuing their own organizational or institutional objectives.

4.0 SUPPORTING MEMBER ORGANIZATIONS

4.1 A Supporting Member is expected to contribute to the development of a comprehensive program of research compatible with its roles and responsibilities.

4.2 A Supporting Member is expected to recognize its obligation to make information widely available by:

(a) providing information to the membership of the Joint Panel on current research which they are supporting:

(b) reviewing reports prepared by other Supporting Members and providing comments:

(c) participating in the activities of the Joint Panel.

4.3 A Supporting Member is expected to recognize the need to make final research results available to the membership and to the public.

4.4 Each organization that is a Supporting Member shall designate an individual as its Representative on the Joint Panel.

4.5 Each Supporting Member shall advise members of the Joint Panel of the individual or unit within their organization to which requests for publication should be directed. This information will be included in the Annual Report.

5.0 THE EXECUTIVE

5.1 The affairs of the Joint Panel will be administered by the Executive.

5.2 The Executive shall consist of the Secretary of the Joint Panel and four other individuals. Each of these other individuals must be the designated Representative of a Supporting Member.

5.3 The individuals who are members of the Executive will be chosen to represent four groups that have Supporting Members on the Joint Panel. the four groups being:

(a) The Federal Government:

(b) The Provincial Government:

(c) Industry: and

(d) Labour.

5.4 It shall be the responsibility of each group to select one individual who will represent the group on the Executive. A selected individual shall serve on the Executive for four years from the 1st of January following his selection.

5.5 All decisions of the Executive shall be by consensus. The Executive may decide any matter placed before it on behalf of the Joint Panel.

5.6 Where a consensus on any matter cannot be reached by the members of the Executive, the question shall be referred to the Supporting Members at the next meeting of the Joint Panel, at which time the matter will be decided by a simple majority vote of the Supporting Members present.

5.7 The Executive is authorized to make news releases, in the name of the Joint Panel, from time to time regarding the functioning of the Panel, its role, and the nature and extent of research being conducted.

6.0 THE CHAIRMAN

6.1 The Executive shall select from among its number an individual to serve as Chairman. The selected individual shall serve as Chairman for 1 year from the 1st of January following his selection.

6.2 The Chairman will preside at all meetings of the Joint Panel and of the Executive.

6.3 In case of the absence of the Chairman from any meeting, any other member of the Executive may preside.

6.4 The Chairman, in consultation with the other members of the Executive, shall be responsible for arranging the meetings of the Joint Panel.

7.0 THE SECRETARIAT

7.1 Energy, Mines and Resources Canada (EMR) will provide the necessary Secretariat and publish the Annual Report.

7.2 EMR will appoint an individual to be the Secretary of the Joint Panel.

7.3 EMR may designate the individual who is the Secretary as their Representative to the Joint Panel, or may designate some other individual.

8.0 MEETINGS

8.1 The Joint Panel will meet semi-annually. Normally there will be a Spring meeting (generally in June) and a Fall meeting (generally in December).

8.2 Each meeting of the Joint Panel will include time for:

(a) conducting business relating to the functioning of the Panel;

(b) distribution of information relating to research projects; and

(c) technical sessions.

8.3 Notice of each meeting shall be sent, by the Secretariat, to the designated Representative of each Supporting Member and to each Associate Member. Included with the notice of meeting will be an agenda.

8.4 Attendance at meetings is restricted to designated Representatives of each Supporting Member, and alternates. Associate Members and observers invited by a member of the Executive. However, technical sessions are open to any interested person at the discretion of the Executive.

9.0 RESEARCH REPORTS

9.1 In order to have a common format for research reports, a system of three forms will be used. The forms will be designated as:

(a) FORM 1: STATEMENT OF PROJECT

(b) FORM 2: REPORT OF PROJECT PROGRESS

(c) FORM 3: PROJECT COMPLETION REPORT

9.2 FORM 1 will be used to advise the members of the Joint Panel of any relevant research project which is to be undertaken or which has commenced but has not previously been reported.

9.3 FORM 2 will be used to advise the members of the Joint Panel of any progress that has been made or of any changes of the scope of a project.

9.4 FORM 3 will be used to advise of the completion or early termination of a project.

9.5 A matrix indicating the various areas of active research of interest to the Joint Panel will be maintained, and each project will be identified as to its position on the matrix.

9.6 A similar matrix indicating areas of completed research projects will also be maintained.

9.7 Each project will be assigned a reference number by the Secretariat. Project reports will be identified by this number.

9.8 A summary of the distribution of active research projects on the matrix will be maintained by the Secretariat, and a copy of this summary will be distributed at each meeting of the Joint Panel.

10.0 TECHNICAL SESSIONS

10.1 The technical sessions held at meetings of the Joint Panel will consist of presentations of invited papers, discussions of current topics and/or field trips.

10.2 It shall be the responsibility of the Executive to organize the technical sessions.

10.3 In selecting papers or topics for presentation at technical sessions, preference will be given to topics related to completed or ongoing research projects.

JOINT PANEL ACTIVITIES - 1987

Two regular business meetings were held during 1987.

Summer Meeting

The summer meeting was held on June 23-24, at the Saskatchewan Research Council in Saskatoon, with Stella Swanson of SRC acting as host. Ten organizations were represented. Sask. HURLE (Human Resources, Labour and Employment), CANMET, AECB, Environment Canada, SRC, DIAND, Sask. Environment, Sask. Mining Association, Key Lake Mining Corp., and the Technical Advisory Committee of AECL.

As well as the usual review of project progress, D. Lawson of Environment Canada presented a poster review of the effects of U nat, Pb-210, Ra-226, and Th-228 on fish exposed to uranium mine tailings. He also commented that a brochure has been prepared for public consumption, tailored to a non-technical audience.

At the technical session, C. Potter of Sask. Environment presented a report on the status of decommissioning projects at uranium mines in Saskatchewan.

A tour of SRC facilities was conducted on June 24.

Fall Meeting

The 1987 fall meeting of the Joint Panel was held at CANMET's Elliot Lake Laboratory. Ten organizations were represented, Sask. HURLE, CANMET, DIAND, NHW, AECB, CAIRS, Key Lake Mining Corp., Rio Algom Mines Ltd., Denison Mines Ltd., USWA, and Ontario Ministry of the Environment. At the technical session, E. Joe of CANMET explained the Reactive Acid Tailings Program. A tour of the Laboratory followed, with a detailed presentation of the radiation instrumentation calibration facility.

On the following day, a field trip to the Eldorado Nuclear Refinery in Blind River took place. An excellent tour was provided by C. Bowser, appreciated by all who attended.

REPORTS BY WORKING GROUPS

High Grade Ores - J. Bigu is reviewing the literature and will mail his findings to P. Duport, AECB, and D. Lawson, Environment Canada.

Internal Dosimetry - The project is complete and a final report should be available soon.

Personal Dosimetry - The report (J. Bigu) will be available soon and will be circulated.

Occupational Hazards - This working group is still under consideration by USWA and AECB.

Close Out Procedure - Presently inactive

ACTIVE RESEARCH PROJECTS

ATOMIC ENERGY OF CANADA LTD. (AECL)

Environmental Effects

101. Environmental pathways analysis - Aquatic (Chalk River).

102. Environmental pathways analysis - Terrestrial (Pinawa).

103. Environmental pathways analysis - Effects of water flow on sorption of radionuclides (Pinawa).

104. Experimental pathways analysis - Sorption of nuclides onto geologic material (Pinawa).

105. Effect of groundwater components on UO_2 dissolution (Pinawa).

106. Actinide - rock interaction (Pinawa).

107. Environmental impact and stabilization of naturally radioactive wastes (Chalk River).

Assessment of Radiation Hazards

108. Quantification of radiation risks (Chalk River).

Radiation Dosimetry

109. Radiation dosimetry and instrumentation development (Chalk River).

110. Internal dosimetry modelling (Chalk River).

111. Deposition of attached and unattached radon daughters (Chalk River).

Assay Methods

112. Bioassay of actinides (Chalk River).

113. *In vivo* monitoring (Chalk River).

ATOMIC ENERGY CONTROL BOARD (AECB)

209. Study of the health effects of inhaled radioactive dust.

210. The Canadian National Dose Registry study.

219. Measurement of the thickness of bronchial epithelium.

220. Ontario miners morbidity follow-up feasibility study.

222. Comparison of the techniques used in estimating past exposures to radon daughters in Canadian mines.

227. Characterization of long-lived dust at a Saskatchewan mine-mill.

228. Movement of radionuclides between water and sediments.

229. The waste management implications of concentrating slimes - II.

232. Determination of radon and thoron fluxes in uranium mines (Ontario).

233. Determination of radon flux in uranium mines (Saskatchewan).

234. Calibration of wire screen collectors in the measurement of the unattached fractions of radon and thoron progeny in air.

235. Modified personal alpha-dosimeter for Canadian uranium miners.

238. Transfer parameter: non-domesticated animals.

239. Effect on radionuclides in plants: literature survey.

240. Transfer of radionuclides to human milk - Phase 2 feasibility.

241. Technical evaluation of an instant working level meter.

242. Catalog of data on uranium uptake, organ burden and excretion.

243. Ontario miners mortality study - an update.

244. Remeasurement of Th-230 in the pore water of Lacnor tailings.

245. Radiation sensitivity of organisms other than man: a review.

246. Effect of soil on radionuclides in plants: a field study.

HIGHLIGHTS, ATOMIC ENERGY CONTROL BOARD - H. Stocker

Since the publication of the 1986 Annual Report, the Atomic Energy Control Board (AECB) has reported on the completion of eight research projects and the publication of six reports.

At the June 23, 1987 meeting of the Joint Panel, the AECB reported that since the previous meeting of the Joint Panel (November 25th, 1986) five research projects had been completed and three reports had been published. The published reports discuss the development of automated laboratory based procedures and equipment for:

i) determining the thorium content of soil samples and aerosols (INFO-2011): and

ii) alpha-particle spectroscopy (INFO-0233).

A third research report on the radionuclide content of fish taken from waters in the vicinity of uranium mines and mills had also been published (INFO-0231-1, INFO-0231-2).

The report "Development of an Automated Method for Determination of Thorium in Soil Samples and Aerosols" describes methods for thorium detection in water, aerosol and solid samples of approximate sensitivities of 1.0 µg/L, 0.5 µg/g and 1.0 µg/g, respectively. At thorium levels of ten times the

detection limit. the accuracy is estimated to be ± 10% for liquids and aerosols, and ± 15% for solid samples. The estimated precision for all samples is ± 5%.

The report "Laboratory System for Alpha-Particle Spectroscopy" (project matrix No. 230) describes a system that can analyze, unattended, ten samples for up to 65,000 seconds per sample.

The report "Survey of Data on the Radionuclide Content of Fish in Canada" presents a compilation, in the form of a computerized database, of uranium and thorium decay-series radionuclide concentrations in various tissues of fish found in Canada. The majority of the data pertains to Saskatchewan, with limited information from Ontario, British Columbia and the Northwest Territories. Most of the radionuclide measurements are of U(total), Ra-226, and Pb-210.

In addition the AECB had published three reports which were prepared by Board staff and pertain to regulatory and licensing concerns for uranium mines and mills:

i) Regulatory criteria for the disposal of radioactive wastes (INFO-0217)

ii) Licencing of uranium mine and mill waste management systems (INFO-0218)

iii) Decommissioning of uranium mines and mills - Canadian regulatory approach and experience (INFO-0219).

Five new research projects were added to the AECB project list. These studies include:

	Title	AECB Ref. No.	Matrix No.
1.	Transfer parameter: non-domesticated animals.	86.4.5	238
2.	Effect of soil on radionuclides in plants: literature survey.	86.4.6	239
3.	Transfer of radionuclides to human milk: phase 2 feasibility.	86.4.9	240
4.	Technical evaluation of an instant working level meter.	86.3.6	241
5.	Catalog of data on uranium uptake, organ burden, and excretion.	86.8.21	242

At the October 28, 1987 meeting of the Joint Panel, the AECB reported that three additional research projects has been completed, and three additional reports had been published. Two of these reports pertain to the transfer of radionuclides through ecological systems:

i) Review of effect of soil on radionuclide uptake by plants (INFO-0230);

ii) Transfer parameters in the water/forage/moose pathway (INFO-0244).

The third report discusses the effect of humidity on inhaled aerosols

in the respiratory tract:

iii) The effect of changes in humidity on the size of submicron aerosols (INFO-0245).

A fourth AECB report had been published that discusses the transfer of radionuclides from the uranium and thorium decay chains through the aquatic and terrestrial environment:

iv) Transfer of radionuclides of the uranium and thorium decay chains in aquatic and terrestrial environments (INFO-0237 (E)).

This report was prepared by a member of the AECB staff and does not correspond to any of the AECB studies listed in earlier Board submissions to the Joint Panel.

The following is a brief presentation of the salient points of these projects.

The report "Review of effect of soil on radionuclide uptake by plants" reviews the available data on the absorption of uranium, thorium, and lead from soils by plant roots and discusses the mechanisms underlying this process. The report also includes an extensive compilation of plant/soil concentration ratios relevant to regions in proximity to Canadian nuclear facilities.

The report "Transfer parameters in the water/forage/moose pathway" presents the findings of a study for which moose tissue samples and associated water and drinking water samples were collected from the Serpent River Drainage Area (study area) and outside of the watershed (controls) during the fall of 1985. No statistical difference was found between study and control samples.

The third report on ecological transfer of radionuclides, "Transfer of radionuclides of the uranium and thorium decay chains in aquatic and terrestrial environments", examines the environmental and experimental factors which cause variations in the transfer coefficient that characterizes the pathway model used in several studies reported on in the literature. The author of the report also formulates generalizations on the transfer of the different radionuclides through the multiple environmental compartments.

The report "The effect of changes in humidity on the size of submicron aerosols", presents the findings of a study that consisted of a literature search and experimental work. It was found that:

1. the size of inhaled natural atmospheric aerosol increases presumably as a result of its partial hygroscopic nature;

2. growth is very sensitive to relative humidity in the range 95-100% (believed to exist in the respiratory tract);

3. supersaturation in the respiratory system may occur on inhaling very cold air; and

4. growth occurs on insoluble particles; surface wettability is believed to be important in the process.

In addition, the influence of ionizing radiation and air ions on the tendency of water vapour to nucleate is discussed.

In addition, four new projects were added to the AECB project list. These studies include:

	Title	AECB Ref. No.	Matrix No.
1.	Ontario miners mortality study - an update.		243
2.	Remeasurement of Th-230 in the pore water of Lacnor tailings.	5.112.1	244
3.	Radiation sensitivity of organisms other than man: a review.	3.116.1	245
4.	Effect of soil on radionuclides in plants: a field study.	3.109.2	246

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS)

HIGHLIGHTS OF CAIRS ACTIVITIES - E. Becker

301. Training - The first radiation safety training module has been completed under a contract to the AECB. The module was demonstrated to government officials in Ontario, Manitoba and Saskatchewan; to uranium company officials in Saskatoon and Elliot Lake; to worker representatives in Elliot Lake, and to Westinghouse in Port Hope.

302. Lung Cancer Detection - Enrolment in the CAIRS Early Lung Cancer Detection Program was up to 2,600 uranium workers in Elliot Lake in early 1988. The program is sponsored by Rio Algom Ltd. and Denison Mines Ltd. It is free to the workers, voluntary and confidential. Recruitment at the two mining companies continues.

303. Personal Alpha-Dosimeters - Phase 1 of a research contract with the AECB and CANMET was completed in 1987. The second phase of the contract continues. The work involves the modification to Canadian mining conditions of a Frencn personal alpha-dosimeter. An agreement with the French Atomic Energy Commission has been reached for CAIRS to produce the new dosimeter heads in Canada under licence to the CEA, subject to successful testing at CEA laboratories in France. The new dosimeter has been tested at the CANMET laboratories in Elliot Lake and at Rio Algom Ltd., and AMOK Ltd. uranium mines.

Radon in Homes - CAIRS concluded tests of a radon-in-homes monitor (based on the CEA personal alpha-dosimeter) with the Saskatchewan and Alberta governments. Development of the new monitor continues.

DENISON MINES LIMITED (DEN)

302. Sputum cytology, Ontario uranium mines (see CAIRS, RIO, USW).

418. Thickened tailings experiment for close-out of uranium mill tailings at Denison Mines Ltd., (CANMET).

As noted in the EMR Highlights, collaborative studies of the underground environment are being conducted on a regular basis.

ENERGY, MINES AND RESOURCES CANADA (EMR)

500. Instrumentation development (to improve and standardize radiation measurement techniques). (DEN.RIO).

501. Environmental radon (thoron) daughter and radioactive dust level determination. (DEN.RIO).

502. Control strategy development (to identify radon and thoron sources and evaluate control techniques at Canadian uranium mines using continuous monitoring techniques. (DEN.RIO).

503. Development of techniques for assessment of air, water and soil contamination by uranium mine tailings areas (includes characterization of tailings and soil profiles). (RIO.DEN).

HIGHLIGHTS OF EMR'S ACTIVITIES - J. Bigu

The objectives are: to develop radiation instrumentation and to undertake studies to determine radiation levels produced in various mining operations; to identify the major factors affecting the release of radioactive products in mine air; and to develop control methods capable of reducing radiation to acceptable levels.

Instrument Development and Technical Evaluation (EMR 500)

Further testing and calibration work has been conducted on a real-time radon daughter monitor using Dynamic Random Access Memory (DRAM) as an α-particle detector. The instrument is commercially available under the name Radon Sniffer. This monitor is manufactured by Thomson and Nielssen (Ottawa), and represents the second generation of an earlier prototype developed under contract with CANMET.

A contract was awarded by AECB to CANMET to evaluate a new radon daughter Instant Working Level Monitor (IWLM) developed by the Commissariat de l'Energie Atomique (CEA), France, and known under the name Mimil. A calibration of the IWLM has been carried out in the Radon/Thoron Test Facility.

A passive radon gas monitor, using diffused-junction detector technology, has been developed by alpha-NUCLEAR with the technical collaboration of CANMET. The instrument is in the prototype stage and has been evaluated in the Radon/Thoron Test Facility (RTTF) along with the Radon Sniffer and the IWLM Mimil referred to above. More recently the monitor has been tested in the field. Recommendations have been made to improve its sensitivity to measure low radon gas concentrations for environmental use.

National Radon/Thoron Test Facility (RTTF)

A radon/thoron test facility (RTTF) to be used as the national facility for testing and calibrating radiation instrumentation used for AECB compliance and other purposes, has been installed at the CANMET/Elliot Lake Laboratory.

Full operation of this facility is expected in 1988.

The RTTF will make available a wide range of:

1. Radon, thoron and arbitrary mixtures of both:

2. Radon daughters, thoron daughters and arbitrary mixtures of both:

3. Variable temperature:

4. Variable relative humidity:

5. Variable aerosol type, concentration and size distribution:

6. Variable air flow rate:

7. Capabilities have been provided for injecting long-lived radioactive dust to simulate underground uranium mine atmospheres. However, no instrumentation for this purpose has been acquired because of lack of funding. The same applies to gas chromatography to measure tracer gases used in plate-out studies, and air residence measurements.

In addition, the RTTF can be operated in either a flow-through, or a recirculating mode. Special provisions have been made to allow for automatic, unattended, control of the radiation level by means of a computer system, dedicated sensors, and a specially developed software package.

Although a number of modifications have yet to be introduced the RTTF has been operating on an experimental basis since late 1986. A great deal of research work has been conducted thus far. This includes studies on the following:

1. Diffusion characteristics of thoron progeny using batteries of metal wire screens of different sizes. This work was conducted in collaboration with the U.S. Bureau of Mines (Denver Research Center).

2. Electrical characteristics of radioactive aerosols (radon and thoron progenies) using a specially designed electrostatic wedge collector; and

3. Plate-out characteristics of radon progeny and thoron progeny on large surfaces of different materials.

Environmental Radiation Level Determination (EMR 501)

Because Long-Lived Radioactive Dust (LLRD), and Radioactive Dust (RD) in general, have become important in radiological protection and health physics, their characterization and quantification cannot be stressed adequately. CANMET has carried out numerous studies of LLRD and RD in Ontario and Saskatchewan uranium mines and mills, in collaboration with interested mining companies.

The most recent study on LLRD and RD has been conducted in conjunction with a large exhaust fan/double filter system used to control dust and radiation in a uranium mine.

Long-lived radioactive dust measurements carried out to date include

concentration, size distribution, activity level, MMAD and AMAD. Identification has been carried out by means of α-spectrometry, γ-spectrometry and fluorometry. The above variables permit the exposure risk from this radiological hazard to be estimated. This work is, therefore, of great practical interest from the radiological protection point of view.

Studies on LLRD and RD will be extended as part of a long-term research program aimed at investigating its radiological impact on uranium industry workers.

A study aimed at investigating the relationship between radon progeny Working Levels, WL(Rn), and thoron progeny Working Levels (Tn), in underground uranium mines has been completed. The work has been carried out at Rio Algom Ltd. (Quirke II, Stanleigh and Panel Mines). In general, a reasonably good correlation between WL(Tn) and WL(Rn) has been established. Hence, measurements of WL(Rn) alone could be used in principle to estimate WL(Tn). This procedure, if implemented, could result in considerable savings in manpower requirements and time. (Knowledge of WL(Tn) is important to calculate the total health risk associated with personal exposure in uranium mines. Total radiation exposure in uranium mines is composed of the following contributions: radon progeny, thoron progeny, long-lived radioactive dust, and gamma-radiation.)

A major project has been initiated in order to analyze data (radon, thoron, and their decay products) gathered by Denison Mines Ltd. during 1986/87. This study is aimed at:

1. Validating radiation mine models: and

2. Determining radon and thoron gas fluxes underground at Denison.

A project has been initiated with the Department of Labour of the Government of Newfoundland and Labrador to design a radiation protection program for the St. Lawrence Fluorspar Ltd. mine. The project will consist partly of a field assessment of the radiation conditions underground followed by recommendations to implement a suitable radiation protection program.

Underground Environmental Monitoring and Control Program (EMR 502)

Radiation, respirable dust and ventilation are three research areas relevant to underground uranium mines. The Elliot Lake Laboratory has recently undertaken a series of combined studies on these areas in collaboration with the local underground uranium mines at Elliot Lake and other non-uranium mines elsewhere. At present the following projects have either been completed or are about to be initiated.

1. Use of wet scrubbers, electrostatic precipitators, e.g., charged water sprays, and mechanical filtration systems to reduce and control long-lived radioactive dust, non-radioactive dust, and radon (thoron) progeny levels in underground uranium mines.

2. Use of ventilation and recirculation as a means of controlling radiation levels in underground uranium and non-uranium mines.

3. Removal of discrete radioactive 'sinks' to improve working radiation conditions in underground mines.

Great emphasis has been placed on radiation control methods and techniques, and an extension of the above projects in a number of different types of mines is being considered for the near future.

Tailings Management to Minimize Environmental Impact - N.K. Dave & T.P. Lim

The project objective is to develop a tailings management technology which is predictive, environmentally safe and cost effective, such that the tailings can be abandoned after inactivity without perpetual treatment or maintenance.

It consists of developing methods of tailings treatment disposal, surface stabilization and cover placement on inactive tailings to reduce the detrimental effects of contaminants transport via wind and water erosion, surface runoff and sub-surface seepage, and hence to minimize the environmental impact.

Thickened tailings experiment for close-out of uranium mill tailings at Denison Mines Ltd (Denison and CANMET) (DEN 418)

An experimental 10,000 tonne thickened tailings pile was constructed in 1982, and its physical and chemical characteristics were measured in detail. Since then the pile has weathered over the last six years. Its characteristic parameters such as physical and chemical stability, saturated and unsaturated zones, hydrogeochemistry, and pore gas oxygen profiles are being reinvestigated to evaluate the use of such a technology as an alternate disposal option for tailings.

Development of techniques for assessment of air, water and soil contamination (Rio Algom, Denison, CANMET, and Laurentian University) (EMR 503)

Techniques are being developed to assess migration of contaminants from uranium tailings via air and water pathways. Radon gas and its progeny profiles are measured in a tailings basin at various depths. The effects of various tailings covers on radon exhalation rates are also investigated to determine suitable covers. Migration of contaminants from tailings to vegetation, to herbivores and insects, and various other food chains are also being studied to evaluate their ultimate impact on man.

ENVIRONMENT CANADA (DOE)

605. Interaction of radionuclides from abandoned uranium tailings with organic residues.

606. Radionuclide distributions in the vegetation of North Saskatchewan and adjacent North West Territories.

607. Radionuclides in Langley Bay, Lake Athabaska, Saskatchewan (includes 609).

608. Effects of uranium effluents on an aquatic ecosystem in North Saskatchewan.

615. Radioactivity and fish.

HIGHLIGHTS ON SELECTED PROJECTS - P. Vasudev

601. Leachability of radioactive constituents from uranium mine tailings (completed).

A series of long-term studies were conducted both to examine the leachability of major constituents and radioisotopes, and to assess the effect of two treatment methods (solidification and vegetation) on the characteristics of leachates from these wastes. Four bench-scale experiments were conducted to study the leachability of old and new tailings.

The results indicated that the addition of the $(Ba,Ra)SO_4$ sediments to tailings results in substantial increases in leached radioactivity for all measured radionuclides except lead-210. It was concluded that if sediments were homogeneously codisposed with tailings at the current mass production ratio, there would, under aerobic conditions, probably be little effect on radionuclide levels in seepage from the tailings.

Results also suggested that solidification of tailings and $(Ba,Ra)SO_4$ sediments, using the Chemfix process, may only delay the release of radionuclides and other substances from the wastes, but will not prevent such a release from eventually occurring.

The vegetation experiments yielded mixed results. Vegetating untreated tailings using a mixture of grasses, to which a layer of sewage sludge was added as a nutrient and source of organic matter, failed over the long term. The leachate from the tailings became acidic as quickly as that from a control portion of the experiment, and the grasses died. Vegetating solidified tailings produced better, but still inconclusive results. The grasses had not died by the end of a seven-year test, but vegetation yields steadily decreased over the duration of the experiment.

It was also concluded that maintaining the Quirke Mine site in a near-saturated state would initially result in lower Ra-226 and SO_4 concentrations. These concentrations, however, would likely be similar once pyrite-oxidizing bacteria had infiltrated the tailings.

607. The effect of uranium mine tailings on radionuclide concentrations in Langley Bay, Saskatchewan.

During the period from 1955 to 1964, the Gunnar Uranium Mine produced approximately 8×10^3 tonnes of uranium oxide and about 5×10^6 tonnes of waste rock and tailings. Large quantities of fine tailings material washed into Langley Bay, a shallow bay opening onto Lake Athabasca. Samples of sediments, fish and macrophytes were analyzed for Ra-226, Pb-210, Th-228 and Uranium.

The sediment data showed the concentrations of radionuclides and some heavy metals to be much higher in Langley Bay than in the control area. Variations in the composition of the Langley Bay sediments may result from the variability of the initial spill of materials from uphill tailings, or from subsequent leaching and depositional effects of runoff and sediment resuspension.

The northern pike and whitefish populations of Langley Bay contained

higher body burdens of radionuclides than those from the control area. The gut contents of whitefish contained the highest concentrations of all four radionuclides in any fish sample from the study. Ingestion of tailings material by these bottom-feeding fish may have increased the radionuclide concentration in the guts.

The question of whether food supply or direct absorption through the gills is the more important path of radionuclide uptake in fish cannot be answered with the present data. Both pike and whitefish are exposed to dissolved radionuclides in Langley Bay water. The effect of this exposure may have been reduced by periodic excursions outside of Langley Bay. Comparing the present data with the extensive review of transfer coefficients presented by Swanson does not clarify the situation. Extensive laboratory work will be required to solve this problem.

Uptake of dissolved materials by macrophytes can occur via roots or submerged foliage depending on species, habitat, and possibly, season. Control (site 1) plant tissues contained higher concentrations of radionuclides than the water at that location, suggesting the ability to concentrate these elements. These plants may act as scavengers for those elements, absorbing radionuclides leached from uphill tailings and depositing them in the sediments when the foliage collapses in the fall.

The study showed that the movement of tailings into Langley Bay has created an area of high radionuclides in sediment and, periodically, in water. Additional material continues to enter the Bay as leachate from the uphill tailings area. These radionuclides have reached high concentrations in the resident whitefish and macrophyte populations, and to a lesser extent, the pike population.

Additional work is currently in progress to: define individual radionuclide variation in the whitefish population; measure the physiological and histopathological impact of high radionuclide concentrations in whitefish; and compare dissolved and food-source pathways of radionuclide uptake.

HEALTH AND WELFARE CANADA (NHW)

703. Bioassay guideline for uranium.

704. Germanium detectors for in vivo measurements.

705. Studies on the solubility of uranium dusts in simulated lung fluid.

HIGHLIGHTS, NHW PROJECTS - M. Limson Zamora, Gary H. Kramer

The bioassay guideline for uranium is in press.

Calibration of the germanium detectors is on-going, but difficulties continue. In-house software is now being tested for the analysis of spectra.

The testing of techniques to simplify the present accepted method of analysis of solubility of uranium dusts in simulated lung fluids continues.

Statistical analysis has commenced for the results obtained in the completed phases of the study relating solubility to aerosol particle size.

INDIAN AFFAIRS AND NORTHERN DEVELOPMENT (DIAND)

801. Modelling the effects of uranium mine tailings on a permafrost environment.

802. Pattern of uranium, companion elements and radioisotopes in lichen heath associated with the uranium deposits near Baker Lake, N.W.T. prior to mining operations.

803. Survey of radionuclides in vegetation, soils and sediments of Keewatin uranium mineralized areas.

804. General use document entitled "Radioactivity in the Northern Environment".

HIGHLIGHTS, DIAND PROJECTS - D.M. Barnett

Three drafts of the document, Radioactivity and the Northern Environment have been completed in an attempt to achieve a satisfactory balance of information and thrust. The project is being re-evaluated, taking into account comments from Joint Panel members.

A key element is the role that northern conditions play in distinguishing this document from other general public documents.

RIO ALGOM MINES LIMITED (RIO)

850. Surface treatment of tailings (CANMET).

302. Sputum cytology, Ontario uranium miners.

As noted in the EMR Highlights, collaborative studies of the underground environment are being conducted on a regular basis with CANMET.

SASKATCHEWAN ENVIRONMENT (SE)

860. Evaluate water quality (ground and surface) in and around 'D' pit (with support from AMOK Ltd).

The field work has been completed with data interpretation and writing to follow.

SASKATCHEWAN RESEARCH COUNCIL (SRC)

912. Compilation and statistical analysis of a data base on uranium-series radionuclides in aquatic biota in northern Saskatchewan (SHRB).

921. Preparation of a brochure and accompanying literature review on radionuclides in fish (DOE).

922. Analysis of caribou bones from the Northwest Territories for uranium-series radionuclides, cesium-137 and strontium-90.

923. Development of bioassays for toxicity testing.

HIGHLIGHTS OF SASKATCHEWAN RESEARCH COUNCIL (SRC) - S. Swanson

922. This project provides data on pre-Chernobyl levels of cesium-137 and strontium-90 in caribou. It also provides data on uranium, thorium, radium-226, lead-210 and polonium-210 levels to be used in relation to results of studies such as Sheard et al. (DOE-29).

923. SRC is currently developing bioassay capability using micro-organisms (algae and cyanobacteria), invertebrates (primarily Ceriodaphnia) and fish (rainbow trout). These tests can be used to test the toxicity of a wide variety of effluents, including uranium mill effluents.

UNITED STEELWORKERS OF AMERICA (USW)

302. Sputum cytology, Ontario uranium miners.

PROJECTS COMPLETED DURING 1987

See also the publications file for reports on active projects by each agency.

Project No.	Agency	Title	Output
		ATOMIC ENERGY CONTROL BOARD (AECB)	
202.		Ontario miners mortality study (Phase II) (MOL. WCB).	
203.		Newfoundland fluorspar miners statistical mortality study (Statistics Canada, NHW).	
204.		Ontario miners 'alive' follow-up feasibility study.	
205.		Ecological dynamics of uranium mill tailings IV.	Cancelled, no publ.
207.		Epidemiological study of lung cancer mortality in Canadian mining communities.	
208.		Ontario miners SIN evaluation study.	
221.		Study of the size change of inhaled submicron aerosols.	
225.		Determination of concentration factors - game animals.	
230.		Laboratory system for alpha-particle spectroscopy.	
236.		Survey of data on the radionuclide content of fish.	
237.		Adapting dosimetric models for use on AECB electronic data processing systems.	
239.		Effect of soil on radionuclides in plants: a literature survey	INFO-0230
		ENVIRONMENT CANADA (DOE)	
601.		Leachability of radioactive constituents from uranium mine tailings.	Report publ. April 1987
603.		CRNL hydrology study.	Report publ. April 1987
612.		Radionuclide content of some Canadian surface waters.	Report publ. May 1987
613.		A discussion of the Environment Canada investigation into radionuclide levels in fish collected from Port Hope harbour.	Report publ. Dec. 1986

614.	A literature review of thorium uptake, retention and excretion.	Final report publ. Nov. 86

SASKATCHEWAN RESEARCH COUNCIL (SRC)

911.	A study of radionuclide transfer in the flooded Gunnar open pit uranium mine.	2 journal articles available from P. Tones
920.	Evaluation of selected aquatic food concentration factors used in the AECL food chain model LIMCAL.	SRC Report E-901-6-A-87
DOE-606	Natural uranium radionuclides in the upland vegetation of Northern Saskatchewan and adjacent Northwest Territories.	Draft report
921.	Preparation of a brochure and accompanying literature review on radionuclides in fish (DOE).	SRC Reports E-901-7-G-87 E-901-2-E-87

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

MATRIX OF RESEARCH AREAS

	OCCUPATIONAL	ENVIRONMENTAL
DEFINE CONDITIONS OF EXPOSURE	AECB 222, 227 232-3-4, 241 AECL 109, 112, 113 CAIRS 302, 303 EMR 501 NHW 705 DEN,RIO,USWA 302	AECB 228, 236, 244, 246 AECL 101, 102, 103, 104, 105 DOE 605-6-7-15 SRC 912, 921, 922
IDENTIFY ADVERSE EFFECTS	AECL 110, 111, 112, 113 EMR 500, 501	AECL 110, 111 DOE 608, 615 EMR 500, 501, 503 DIAND 801, 802, 803, 804 SE 860 SRC 923
RELATE EXPOSURE WITH EFFECT	AECB 209, 210, 220, 242 AECL 108, 110-11-12-13	AECB 239, 240, 245 AECL 108, 110, 111 DOE 615
ASSESS RISK	AECB 219, 235, 243 AECL 108 USW 990	AECB 238 AECL 101, 102 108 DEN 418, 419
CONTROL HAZARD	EMR 502 NHW 703, 704	AECB 229 AECL 107 DOE 601, 605 EMR 503 RIO 850

FORM 4/84

PUBLICATION FILE

The first Annual Report of the Joint Panel for Occupational and Environmental Research for Uranium Production in Canada was produced in 1977.

This publication file contains references for only the current year, 1987, and the two preceding years, 1985 and 1986. The annual report for 1983 contains all previous lists of publications, as do earlier annual reports.

Publications should be obtained from the public literature or from the organization conducting or sponsoring the work.

The publication list includes specific project reports by member agencies, as well as other reports of relevance not necessarily associated with the projects listed in the Active Projects section.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1985.

1. Phillips, C.R., Khan, A., Leung, H., "Development of diffusion - based radon daughter dosimeters", INFO-0012.

2. R.A.D. Service and Instruments Ltd., "Design of the passive personal dosimeter for mines using an allyl diglycol carbonate plastic - phase I: basic and feasibility study", INFO-0117.

3. Corkill, D.A., Dory, A.B., "A retrospective study of radon daughter concentrations in the workplace in the fluorspar mines of St. Lawrence, Newfoundland", INFO-0127.

4. Chiu, N.W., Dean, J.R., Sill, C.W., "Techniques of sample attack used in soil and mineral analysis - phase I", INFO-0128-1.

5. Archibald, J.F., "Membrane barriers for radon gas flow restrictions", INFO-0130.

6. Friesen, Kaye and Associates, "An evaluation of the uranium mine radiation safety course", INFO-0182.

7. Ching, S.H., "Derived surface contamination limits for the uranium mining and milling industry", INFO-0138.

8. IEC Beak Consultants Ltd., "Probabilistic calculation of dose commitment from uranium mill tailings", INFO-0139.

9. Linauskas, S.H., Kalos, F., "Study of the efficiency and current use of respiratory protective devices", INFO-0144.

10. Senes Consultants Ltd., "Computer modelling of an underground mine ventilation system", INFO-0145.

11. Avadhanula, M.R., "Dissolution studies of UO_2 in simulated lung fluid", INFO-0147.

12. Dean, J.R., Chiu, N.W., "Analysis of techniques of sample attack for soil and mineral analysis - phase II", INFO-0128-2.

13. DSMA Atcon Ltd., "Elliot Lake study: factors affecting the uranium mine working environment prior to the introduction of current ventilation practices", INFO-0154.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1986

1. DSMA Atcon Ltd., "Comparison of radon and thoron daughter behaviour in two underground uranium mine environments", INFO-0164.

2. Beak Consultants Ltd., "Derivation of release limits for a typical uranium mining and milling facility", INFO-0165.

3. Duport, P.J. and Edwardson, E., Canadian Institute for Radiation Safety. "Determination of the contribution of respirable long-lived dust to the committed dose equivalent received by uranium mine and mill workers in the Elliot Lake area". INFO-0167-1.2.

4. SENES Consultants Ltd., "Electrostatic purification of uranium mine stope atmospheres", INFO-0173.

5. Walsh, M.L., W & W Radiological and Environmental Consultant Services Inc., "Doses resulting from intrusion into uranium tailings areas". INFO-0182.

6. McElroy, R.G.C. and Johnson, J.R., AECL, Chalk River Nuclear Laboratories. "Passive radon daughter dosimeters". INFO-0184.

7. Phillips, C.R. and Khan, A., University of Toronto, "Analysis of factors affecting aerosol, unattached fraction and radon progeny measurements in mines", INFO-0187.

8. Beak Consultants Ltd. and Golder Associates. "Waste management implications of concentrating slimes - characteristics and potential problems", INFO-0195-1.

9. Beak Consultants Ltd., "The cost of decommissioning uranium mill tailings", INFO-0198.

10. Robertson, R., Becquerel Laboratories Inc., "Feasibility study of the dissolution rates of uranium ore dust, uranium concentrates and uranium compounds in simulated lung fluid", INFO-0205.

ATOMIC ENERGY CONTROL BOARD (AECB): Listings for 1987

1. "Development of an automated method for determining the thorium content of soil samples and aerosols" INFO-2011.

2. "Laboratory system for alpha-particle spectroscopy", INFO-0233.

3. "Survey of data on the radionuclide content of fish in Canada", INFO-0231-1, and INFO-0231-2, Appendix.

4. "Regulatory criteria for the disposal of radioactive wastes", INFO-0217.

5. "Licensing of uranium mine and mill waste management systems", INFO-0218.

6. "Decommissioning of uranium mines and mills - Canadian regulatory approach and experience". INFO-0219.

7. "Review of effect of soil on radionuclide uptake by plants". INFO-0230.

8. "Transfer parameters in the water/forage/moose pathway". INFO-0244.

9. "The effect of changes in humidity on the size of submicron aerosols". INFO-0245.

10. "Transfer of radionuclides of the uranium and thorium decay chains in aquatic and terrestrial environments". INFO-0237 (E).

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1985

1. Avadhanula, M.R., Chatterjee, R.M., Healey, G.J., Horvath, F.J., Measures, M.P., Stocker, H., Pomroy, C., Johnson, J.R. and Dunford, D.W., "Canadian uranium fuel fabrication study: I intake, retention and excretion monitoring results. II comparison of results with metabolic models. Symp. on the Assessment of radioactive contamination in man". Intern. Atomic Energy Agency, Vienna, pp. 297-323, 1985.

2. Champ, D.R., Young, J.L., Robertson, D.E., Abell, K.H., "Chemical speciation of long-lived radionuclides in a shallow groundwater flow system", Water Pollution Research J. of Canada, 19, 35-54, 1984.

3. Champ, D.R., Moltyaner, G.L., Young, J.L. and Lapcevic, P., "A downhole column technique for field measurement of transport parameters". AECL-8905, 1985.

4. Davis, J.L., Killey, R.W.D., Annan, A.P. and Vaughan, C., "Surface and borehole ground penetration radar surveys for mapping geological structure", Proc. of the NWWA/EPA Conf. on Surface and Borehole Geophysical Methods, February 07-09, 1984.

5. Jay, P.C., "Anion contamination of environmental water samples introduced by filtration procedures", Analytical Chemistry, v.57, No. 3, pp 780-782, 1985.

6. Jay, P.C. and Judd, J.M., "The determination of common anion concentrations in surface and groundwater samples by eluent suppressed ion chromatography", Intern. J. Environ. Anal. Chem., v.19, pp. 99-109, 1984.

7. Johnson, J.R., "The relative effect of ventilation on the potential α-energy from ^{222}Rn and ^{220}Rn progeny, Health Physics 49, pp 996-998, 1984.

8. LaFleur, D.W., Pickens, J.F. and Killey, R.W.D., "Hydrogeologic assessment of the 233-Lake area: calibration of a 3-D groundwater model", TR-257, 1985.

9. Lee, D.R. "Method for locating sediment anomalies on lakebeds that can be caused by groundwater flow", J. Hydrol, 79, 197-193, 1985.

10. Male, D.H., "Wind transport of soil aerosols", Technical Record, TR-295, 1985.

11. Moltyaner, G.L., Sudicky, E.A. and Cherry, J.A., "Contaminant transport in heterogeneous porous media: characterization of spatial variability and dispersivity at a field site", Technical Record, TR-258, 1985.

12. Munch, J.H. and Killey, R.W.D., "Equipment and methodology for sampling and testing cohesionless sediments", Groundwater Monitoring Review, vol. 5, No. 1, pp 38-42, 1985.

13. Patterson, M.C., Gentner, N.E., Middlestadt, M.V., Mirzayans, R. and Weinfeld, M., "Hereditary and familial disorders linking cancer proneness with abnormal carcinogen response and faulty DNA metabolism", Epidemiology and Quantitation of Environmental Risks in Humans from Radiation and Other Agents, pp 235-267, Plenum Corp., 1985.

14. Peterman, B.F., "Thoron-in-breath monitoring at CRNL", Report AECL-8706, 1985.

15. Olivier, J.P., Osborne, R.V. and Rafferty, P.J., "Long-term management of uranium mill tailings: results of the OECD/NEA study", AECL-8499, 1984.

16. Sheppard, M.I., "Radionuclide partition coefficients in soils and plants and their correlation", Health Physics, 49, pp 106-111, 1985.

17. Sheppard, M.I. and Sheppard, S.C., "The plant concentration factor concept as applied to natural uranium", Health Physics 48, pp 494-500, 1985.

18. Wuschke, D.M., Gillespie, P.A. and Main, D.E., "Second interim assessment of the Canadian concept for nuclear fuel waste disposal. vol. 1 - summary", Report AECL-8373-1, 1985.

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1986

1. Cornett, R.J., Chant, L. and Link, D., "Sedimentation of Pb-210 in Laurentian Shield Lakes": Water Pollution Research J. of Canada, vol. 19, pp 97-109, 1985.

2. Lee, D.R., "Method for locating sediment anomalies on lakebeds that can be caused by groundwater flow", J. of Hydrology, vol. 79, pp 187-193, 1985.

3. Champ, D.R., Moltyaner, G.L., Young, J.L. and Lapcevic, P., "A downhole column technique for field measurement of transport parameters", AECL-8905, 1985.

4. Moltyaner, G.L. and Killey, R.W.D., "Field studies of dispersion in porous media: analysis of experimental data", EOS vol 65, p 208, 1984.

5. Munch, J.H. and Killey, R.W.D., "Equipment and methodology for sampling and testing cohesionless sediments", Groundwater Monitoring Review, vol 5, pp 38-42.

6. Zach, R. and Barnard, J.W., "EWAM: a model for predicting food and water ingestion, and inhalation rates of man", AECL-8401, 1985.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1985

1. CAIRS Annual Report, March 31, 1985.

2. "Determination of the contribution of long-lived dust to the committed dose equivalent received by uranium mine and mill workers in the Elliot Lake area", report on research completed under contract to the Atomic Energy Control Board of Canada, November 1985.

3. "The uranium mine radiation safety course", UMRSC 2/85, October 1985.

4. "Radiation safety training in uranium mines and mills: a CAIRS proposal", 1985. Title amended in February 1986 to "Radiation safety training in uranium and other mines and mills".

5. "Progress report on CEA dosimeter performance", December 1985.

6. "Proposal: modified personal alpha dosimeter for Canadian uranium mines", January 1986.

7. "Lung cancer detection, a CAIRS program for Ontario uranium miners", January 1986.

8. "Radiation? who cares? CAIRS cares / CAIRS. Qu'est-ce que c'est?" a bilingual brochure on CAIRS' purpose, programs and activities.

9. "Radiation safety bulletin", vol. 4, No. 1, April 1986. Bulletin de radioprotection.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1986

1. Action on radiation. The CAIRS action plan to assist Canadians exposed to radiation in the workplace, 1987-1990.

2. CAIRS radiation safety bulletin, vol. 4, No. 1 and 2.

3. Bancroft uranium tailings. Information obtained by CAIRS from the Federal and Ontario governments.

4. Reports on uranium mine radiation safety course, 1/86 and 2/86.

5. Radiation safety for Canadians. An invited brief to the new democratic party's inquiry into nuclear energy.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1987

1. "All about radiation". A radiation safety training program for Canada's uranium mine and mill workers. Training manual for Module 1.

2. CAIRS Radiation Safety Bulletin. vol. 5, No. 1 and 2.

3. "Radioactive and toxic wastes from the Bancroft uranium mines. Where are we going? Who is in charge?" CAIRS Report Stage II.

4. "Report: the uranium mine radiation safety course". 1/87 and 2/87.

5. The CAIRS List 1987-1988, La Liste CAIRS. Radiation Safety Training in Canada. Cours de radioprotection au Canada.

ENERGY MINES AND RESOURCES CANADA (EMR): Listings for 1985

1. Dave, N., Lim, T.P. and Cloutier, N., "Ra-226 concentrations in blueberries (Vaccinium Angustifolium Ait.) near an inactive uranium tailings site in Elliot Lake, Ontario, Canada", Division Report MRP/MRL 85-28, CANMET, Energy, Mines and Resources Canada, 1985.

2. Bigu, J., "Theory of diffusion of radon and thoron through membranes under steady-state and time-dependent radiation conditions - part I (steady-state case)", Division Report MRP/MRL 85-51, CANMET, Energy, Mines and Resources Canada, 1985.

3. Bigu, J., "Theory of diffusion of radon and thoron through membranes under steady-state and time-dependent radiation conditions - part II (time-dependent case)", Division Report MRP/MRL 85-52, CANMET, Energy, Mines and Resources Canada, 1985.

4. Bigu, J., "Theoretical considerations regarding the behaviour of a mine model with ventilation under time-dependent radiation conditions", Division Report MRP/MRL 85-53, CANMET, Energy, Mines and Resources Canada, 1985.

5. Bigu, J., "Theoretical considerations regarding the growth and decay of the short-lived decay products of radon and thoron plated-out on large surfaces", Division Report MRP/MRL 85-54, CANMET, Energy, Mines and Resources Canada, 1985.

6. Grenier, M., "Program ALPHAPRINT for the processing of data acquired by an AlphaNUCLEAR Ltd. logger system", Division Report MRP/MRL 85-64, CANMET, Energy, Mines and Resources Canada, 1985.

7. Bigu, J., "Thoron determination using activated carbon and a high purity germanium detector", Division Report MRP/MRL 85-71, CANMET, Energy, Mines and Resources Canada, 1985.

8. Bigu, J. and Frattini, A., "Radon progeny and thoron progeny plate-out on a variety of materials", Division Report MRP/MRL 85-72, CANMET, Energy, Mines and Resources Canada, 1985.

9. Bigu, J., "Theoretical considerations regarding active sampling of time-dependent radon (thoron) atmospheres", Division Report MRP/MRL 85-75, CANMET, Energy, Mines and Resources Canada, 1985.

10. Dave, N., Lim, T.P. and Cloutier, N., "Migration of metals and trace radionuclides from mine tailings to the environment", Division Report MRP/MRL 85-80, CANMET, Energy, Mines and Resources Canada, 1985.

11. Bigu, J. and Grenier, M., "Characterization of radioactive dust in Canadian underground uranium mines", Division Report MRP/MRL 85-81, CANMET, Energy, Mines and Resources Canada, 1985.

12. Grenier, M., "On-filter self-absorption and loading characteristics", Division Report MRP/MRL 85-83, CANMET, Energy, Mines and Resources Canada, 1985.

13. Bigu, J., "Theory and application of radon and thoron progeny monitoring under steady-state and non-steady-state radiation conditions - part I: active sampling", Division Report MRP/MRL 85-88, CANMET, Energy, Mines and Resources Canada, 1985.

14. Bigu, J., "Progress during the first half of 1985 in the environment projects of the CANMET minerals program", presented to Joint Panel at Chalk River, Ontario, 25-26 June, 1985. Division Report MRP/MRL 85-90, CANMET, Energy, Mines and Resources Canada, 1985.

15. Bigu, J., "Theory and application of radon and thoron progeny monitoring and steady-state and non-steady-state radiation conditions - part II: passive sampling", Division Report MRP/MRL 85-91, CANMET, Energy, Mines and Resources Canada, 1985.

16. Bigu, J., "The effect of time-dependent ventilation rates in partially enclosed radioactive environments", Division Report MRP/MRL 85-92, CANMET, Energy, Mines and Resources Canada, 1985.

17. Bigu, J. and Kaldenbach, R., "A microprocessor based continuous monitor with alpha-spectroscopy capabilities for the determination of radon, thoron and their progeny", Division Report MRP/MRL 85-115, CANMET, Energy, Mines and Resources Canada, 1985.

18. Bigu, J. and Grenier, M., "Electrical characteristics of the short-lived decay products of thoron in underground mines", Division Report 85-116, CANMET, Energy, Mines and Resources Canada, 1985.

19. Bigu, J., "Plate-out of radon and thoron progeny on different materials", Division Report MRP/MRL 85-117, CANMET, Energy, Mines and Resources Canada, 1985.

20. Bigu, J., "A method for determining thoron and radon gas concentrations using solid-state alpha-particle detectors", Division Report MRP/MRL 85-120, CANMET, Energy, Mines and Resources Canada, 1985.

21. Bigu, J., "An automated multisensor apparatus for comparative membrane radon and thoron permeability studies", Division Report MRP/MRL 85-123, CANMET, Energy, Mines and Resources Canada, 1985.

22. Bigu, J., "Attachment of radon and thoron progeny to the surface of different materials", Division Report 85-130, CANMET, Energy, Mines and Resources Canada, 1985.

23. Bigu, J., "Progress during the second half of 1985 in the environment projects of the CANMET minerals program", presented to the Joint Panel in Toronto, December 1985. Division Report MRP/MRL 86-1, CANMET, Energy, Mines and Resources Canada, 1986.

24. Bigu, J., "Theoretical models for determining radon and thoron daughter levels in Canadian underground uranium mines - a comparison with experimental data", Health Physics vol 48, No. 4, pp 371-399, April 1985.

25. Bigu, J., "Use of an automated fluxmeter employing solid-state diffused-junction alpha-detectors and a meteorological package to determine surface radon flux", IEEE Transactions on Nuclear Science, vol NS-31, No. 6, pp 1599-1606, December 1984.

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JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

APPENDIX

DATE	STATEMENT OF PROJECT	PROJECT #

TITLE	MATRIX LOCATION

OBJECTIVE

SCOPE OF WORK	ANTICIPATED COST

RESEARCHER(S)	ANTICIPATED COMPLETION DATE

SPONSOR(S)	CONTACT

FORM 1/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	REPORT ON PROJECT PROGRESS	PROJECT #

TITLE	MATRIX LOCATION

PROGRESS/STATUS

CHANGES	ANTICIPATED COST ANTICIPATED COMPLETION DATED

SPONSOR(S)	CONTACT

FORM 2/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	PROJECT COMPLETION REPORT	PROJECT #

TITLE	MATRIX LOCATION

DISPOSITION/STATUS

(Please quote abstract of publication if appropriate)

PUBLICATION AVAILABILITY	FINAL COST

SPONSOR(S)	CONTACT

FORM 3/84